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AN EMPIRICAL ANALYSIS OF WARRANT PRICES VERSUS LONG TERM CALL OPTION PRICES

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AN EMPIRICAL ANALYSIS OF WARRANT PRICES VERSUS LONG TERM CALL OPTION PRICES

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AN EMPIRICAL ANALYSIS OF WARRANT PRICES VERSUS LONG TERM CALL OPTION PRICES

Abstract

This paper empirically investigates the pricing behavior of warrants. Based on the premise that warrants and long term call options are similar contracts with respect to the same underlying value, an empirical test is conducted which evaluates the difference between the implied standard deviation, measured for both contracts at the same time. In the case of Dutch warrants and long term call options (with maturities up to several years), this study reveals that warrants are considerably overvalued. Moreover, this overvaluation persists over the entire research period and does not appear to be attributable to possible market imperfections or institutional factors.

1 Introduction

In their well-known warrant pricing paper Galai and Schneller (1978) demonstrated that otherwise identical warrants and call options, should have the same price. No empirical research that confronts this result with actual data appears to be available, which is probably caused by the fact that warrants usually have a much longer time to maturity than call options. However, this is not the case for the Dutch capital market. Since 1986, the European Options Exchange (EOE) in Amsterdam provides for trading in call and put options on individual stocks with maturities up to a maximum of five years. In the last few years, these long term option contracts have become increasingly popular among investors in the Netherlands, resulting in steady growing trading volumes and considerable open interest positions[1,2]. Moreover, at the Amsterdam Stock Exchange (ASE) warrants and covered warrants are being traded. This Dutch institutional feature enables us to carry out a new test, i.e. a comparison of warrant prices versus long term call option prices. In this paper we will analyze a data-set containing prices of warrants and call options that were traded in Amsterdam from April 1, 1987 until September 30, 1989. The composition of the data-set is described in table 1.

[Insert Table 1]

Because the maturities and exercise prices of warrants and call options are hardly ever exactly the same, we suggest the comparison of implied standard deviations from warrants and call options written on the same underlying stock. This test reveals that warrants appear to have substantial higher market prices than the concomitant long term call option contracts. This result turns out to be robust to the choice of either the Binomial model, the Merton model or the Square Root CEV model to compute the implied standard deviation.

This paper is organized as follows. In section 2 we will first of all consider the Philips example where a call option that had a longer maturity and a lower exercise price than the warrant was traded at prices below the prices that were paid for the warrants for a period of at least sixteen months. This example suggests that warrants might be overpriced compared with long term options. In order to analyze this question in more detail we discuss in section 3 how the implied standard deviation can be used to compare prices of options and warrants where such straightforward deviations from the Galai and Schneller (1978) result do not appear. The empirical analysis of the implied standard deviations is presented in section 4. In section 5 additional evidence is presented with regard to short term call options.

2 A direct comparison of warrant and call option prices

We have first investigated whether conclusions can be drawn from a *direct* comparison of warrant and call option prices. In case a warrant and a call option are contingent on the same underlying common stock, and no special conditions exist for the warrant, the warrant and the call option will only differ with respect to the exercise price and/or the maturity. Therefore, if a call option both has a longer maturity and a lower exercise price than a warrant contingent on the stock of the same firm and both contracts are evaluated at the same date, stochastic dominance arguments suggest that the call option should be valued higher than the warrant. Of course, the reverse case holds as well. We have first investigated whether our sample, which will be described in more detail in section 3, contains examples of warrant/call combinations that yield clearcut empirical evidence against this stochastic dominance result.

In our research period both 5-year call options introduced in 1986 and warrants issued in 1984 were outstanding with respect to the Dutch company Philips. In this section these will be referred to as '(call) options' and 'warrants' respectively. The exercise price (in Dutch guilders) of the options was 55, while the warrants had an exercise price of 63. On April 1, 1987 the options had a remaining maturity of 1661 days, while the maturity of the warrants was only 974 days. No 'special conditions' applied to these warrants. Because the options had both a longer maturity and a lower exercise price than the warrants, the options would be expected to have a higher price than the warrants. In figure 1 market prices for the options and warrants are compared for 2 years of the research period.

[Insert Figure 1]

The market price of the warrants is divided by the warrant-ratio in order to derive the price to buy one share of common stock. From figure 1 we conclude that until July 1988 the warrant price was higher, and at some dates much higher, than the call option price. This contrasts to what a priori would be expected. In the appendix we have investigated whether the price differentials between warrants and long term call options may generally be explained by market imperfections. From the appendix we conclude that no tax differentials exist between warrants and call options and that dividend protection and liquidity are in some cases more favorable for warrants and in other cases more favorable for call options. Another aspect, standardization, favors call options over warrants. Also two factors favor warrants over call options, i.e. transaction costs and the relation of the warrant-ratio to the option-ratio. However, these factors only seem to be important if small amounts of warrants and call options are considered. Therefore it is concluded that no important differences exist between warrants and long term call options, that can explain the substantial price differentials found in the Philips example.

Violations of the price ordering implied by stochastic dominance, like the Philips example discussed above, are rare in the data-set. Of course that does not imply that warrants cannot be overpriced for other firms and/or in other periods as well. In order to detect such possible mispricing we have to develop a test procedure that enables us to compare warrant and long term call option prices in general. This test procedure will be outlined in section 3.

3 A general test procedure for warrants and call options

The most important difference between a warrant and a call option is that upon exercise of a warrant new shares are created. This effect is known as the 'dilution effect'. Of course the dilution effect has an impact on both the option and the warrant prices, because the underlying stock reflects the potential dilution (see e.g. Galai (1989)). Schulz and Trautmann (1989) and Crouhy and Galai (1991a) have developed a version of the Black-Scholes (1973) model corrected for dilution, but which is more difficult to handle than the original Black-Scholes model. However, Schulz and Trautmann (1989) and Bensoussan, Crouhy and Galai (1992) have shown that the difference between unadjusted Black-Scholes warrant prices and warrant prices using the Black-Scholes model corrected for dilution are very small, even for extremely high dilution factors. Given this evidence we have simply used pricing models that do not adjust for dilution[3].

When a particular option pricing model is used, several variables have to be estimated in order to calculate a model price. Most pricing models, especially the ones in the present study, include a common set of six variables. Three of these are directly observable: the current stock price, the exercise price and the remaining time to maturity, while two other variables can be estimated with a high degree of certainty: the risk-free interest rate and the future dividend payments. In fact there seems to be only one variable which is generally difficult to estimate: the volatility of the underlying stock. However, this single unknown variable can be estimated using the market price of the contract as determinate. This reverse procedure boils down to finding the implied volatility or implied standard deviation (ISD).

As Merton (1973) has demonstrated, the option price is a strictly increasing function of the volatility. This property is extremely useful in our empirical research. It allows us to consider the stock price volatility as representing the option price. In particular, the ISD-value represents the market price of the derivative contract. It is important to note that, given the process assumed with respect to stock price movements, the ISD-value is an estimator of a property attributable to the underlying stock price. Consequently, at a particular moment in time there is no reason to expect different ISD-values when comparing different contracts contingent on the same underlying security, provided the model used holds for these contracts. Therefore, we propose the following testable hypothesis, i.e. *measured simultaneously, warrant and (long term) call option ISD-values are equal.*

Before carrying out this test, some other theoretical aspects have to be discussed first. One of these is a finding in option pricing literature, by e.g. Beckers (1981), that call options series with differing maturities seem to have different ISD-estimators. Kemna (1988) investigates this feature for the EOE, by comparing ISD-values for three samples of call options series, i.e. calls expiring within 3, 6 or 9 months. She finds evidence consistent with the existence of a so-called 'term structure of volatility', which implies that investors would associate a particular time horizon with a certain measure of stock price volatility. In her sample call options with a shorter maturity (up to 3 months) have significant lower ISD-values than call options with a longer maturity (up to 9 months)[4]. This is an important point to consider in studies like the present one. If we were to compare ISD-values of (long term) warrants with ISD-values of common (short term) call options, differences could be attributed to a particular prevailing term structure. To avoid this problem, this study compares prices of warrants and long term call options, which are instruments with strongly resembling maturities. Therefore we implicitly diminish mispricing problems caused by volatility term structures.

A second point to consider is that, according to Galai (1983), empirical tests of option pricing models (such as the B/S-model) often show considerable prediction errors when in- or out-of-the-money options are analyzed. This kind of possible misspecification can be expressed as the existence of an 'exercise price bias'. If a model used in our study is in fact misspecified in this way, a serious complication would be introduced. As indicated above, warrant exercise prices will normally deviate from long term call option exercise prices. In order to prevent this problem we have used several option pricing models, including the CEV model. This model is able to, at least partially, explain the exercise price bias by an increased (decreased) stock price volatility associated with lower (higher) stock prices (see e.g. Hull (1989)).

As a final remark, it should be noted that the existence of either a term structure of volatility or an exercise price bias does not explain the results found for the Philips example in section 2. Because it entails a clear violation of stochastic dominance rules, finance theory claims it should not exist to begin with and it should certainly not persist over such a long time.

4 Empirical research

4.1 Data description

In order to test whether warrant ISD-values are equal to long term call option ISD-values, it was first decided which models to use for the calculation of ISD-values. Both with respect to the pricing of call options and warrants, empirical tests show conflicting results when the performance of models of the Constant Variance (CV-)class is compared with the performance of models of the Constant Elasticity of Variance (CEV-)class[5]. Therefore we have included models of both classes.

The relatively long time to maturity of the type of contracts studied caused for an explicit consideration of dividends. Since it does not account for this, the original Black-Scholes model was neglected. We have selected two models of the CV-class that include dividend payments: the Merton model and the Binomial model and one model of the CEV-class that also contains dividend payments: the Square Root CEV model corrected for continuous dividend payments. The Binomial model used in the present study considers discrete dividend payments at each ex-dividend instant. However, such dividends cause the binomial tree to become very complicated when a considerable number of dividend payments is included. Therefore we assume that the total future dividend payment (up to the expiration date) on the underlying stock is paid out in two discrete moments, i.e. at one-third and two-third of the maturity of the option[6]. The Merton model and the (adjusted) Square Root CEV model, on the other hand, are models that account for continuous dividend payments.

Using these three models ISD-values were calculated for each contract listed in table 1, as long as it existed in the sample period. We constructed weekly ISD values. To derive these, we collected weekly data for the period of April 1 until September 30 for the years 1987 (27 observations), 1988 (26 observations) and 1989 (26 observations). The period of April 1 to September 30 is chosen in order to see if there is a trend over the years. Furthermore the choice of this period enables us to exclude, as much as possible, the effects of the October crash of 1987. According to Beckers (1981) a problem occurs if closing price data are used, because the closing price reflects the price at which the last trade took place, while it is unknown whether this trade took place at the bid price, the ask price or some price in between. Beckers argues that this uncertainty influences the ISD-calculations at a specific day. However, he argues, this problem diminishes when averaging over a number of days. Therefore he suggests to calculate an unweighted average ISD for a number of days. Based on Beckers' arguments a three-day arithmetic average was calculated as ISD estimator for each week[7].

With respect to the availability of long term call options we observe that from 1986 each year (in October) one new series of 5-year call options is introduced, with an exercise price close to the then prevailing stock price. Therefore in 1987 only one series of long term call options was available for each stock, while in 1988 and 1989, two and three series were available. In order to give an indication of the 'term structure of volatility', we have also calculated ISD-values for short term call options for which the series with the longest maturity is included, i.e. the series with an initial maturity of 9 months. Each time a new series of 9 month call options is introduced, i.e. on the third friday of April and July respectively, the old series are replaced by these new series, so that ISD-values are always calculated from the longest maturity series of short term call options. In contrast to long term call options, several series of 9-month call options with different exercise prices are outstanding at the same date. Following Becker's (1981) method we selected on each day the ISD-value with the highest value for the derivative from the option price to the standard deviation.

Market prices of warrants, call options and underlying stocks have been derived from the Dutch financial newspaper "De Officiële Prijscourant", an official publication of the stock and options exchanges in Amsterdam. From the same newspaper the exercise prices and maturities of the call options have been collected. Information on the warrant-ratio's, exercise prices and maturities of the warrants was derived from the issuance prospectuses. In a number of cases the warrant-ratio's and/or exercise prices have been adjusted due to the application of anti-dilution clauses. Information on these adjustments is taken from announcements published in the Dutch financial newspapers "De Officiële Prijscourant" and "Het Financieele Dagblad". The riskless interest rate was estimated as the daily average yield on government bonds with a maturity of 3 to 5 years, which was also derived from "De Officiële Prijscourant". For the period from April 1 until September 30 in year t the dividend yield, which is required in both the Merton and the Square Root CEV model, is taken to be the ratio of the dividend paid in the period April 1 of year t-1 to March 31 of year t, over the average stock price in that period, which was estimated as the average of the closing stock prices realized on the first trading day of each month.

In case market prices of warrants or options on a per share basis were lower than 50 cents the observation for that particular day was excluded. A reason for this is that in such a situation the bid-ask spread will typically be large relative to the price of the warrant or call option, which makes the ISD-estimates very unreliable. After examination this turned out to be only relevant for the warrants Philips 1983, which from April 1, 1988 to the expiration date (July 15, 1988) were listed at a price less than 50 cents on a per share basis.

Finally, we note that some of the warrants included in table 1 contain special conditions. This is the case for the warrants Akzo 1986, which are callable to the extent that from November 1, 1988 the company has the right to shorten the maturity of these warrants. It only has the obligation to inform the warrant holders three months before the call date. If the warrants are called, the warrant holder has the choice between exercising his warrant or holding it until expiration. In the trust agreements of some other warrants the company has included the right to (temporary) reduce the exercise price. This is the case for the warrants ABN 1986, AMRO 1986S, KLM 1983 and KLM 1985. We notice that this right was only seldom used by Dutch companies.

4.2 Test results

Using the argument outlined above that volatility is a property associated with the fluctuations of the stock price, the ISD-values simultaneously determined for a warrant and a long term call option should be compared to each other. Therefore, we identified weekly observations for the difference between these coupled ISD-values, i.e.

$$WD_{it} \equiv ISD_{it}^{w} - ISD_{it}^{lc} \tag{1}$$

such that WD_{it} is defined as the difference between the warrant ISD (ISD_{it}^{w}) and the long term call ISD (ISD_{it}^{lc}) for warrant-call combination i in week t. A total of 27 weeks were included for 1987, and 26 weeks for the other years. Since these periods are separated by 6 months, the week index t was chosen such that t = 1, 2, ... , 27 for 1987, t = 54, 55,

... , 79 for 1988, and t = 106, 107, ... , 131 for 1989. The total number of combinations that could be analyzed amounted to 6 in 1987, 8 in 1988 and 12 in 1989:

- in *1987* the warrants Akzo 1986, KLM 1983 and 1985, Philips 1983 and 1984 and the covered warrants Royal Dutch were compared with the long term call options of these companies that were issued in 1986;
- in *1988* the warrants KLM 1983 were no longer outstanding and the warrants Philips 1983 all had prices (on a per share basis) less than 50 cents; on the other hand, the long term call options issued in 1987 could be included in the analysis;
- in *1989* the long term call options issued in 1988 were added.

Suppose it is assumed that each individual WD_{it} observation is independent and identically distributed with zero mean and unknown (but equal) variance. In such a situation we may carry out an initial test by averaging over the sample observations and check whether the sample mean is equal to zero. Panel (a) in table 2 provides summary data for this test.

[Insert Table 2]

It can be noted from this table that the mean weekly ISD-difference is positive, and the corresponding t-statistics reveal that the means are all significantly different from zero at the 1% level for the entire research period, for each year included and for each model investigated. It is also clear that many, though not all, observations are in fact positive. The positive skewness and (centered) kurtosis figures indicate that the *WD*-distribution is skewed to the right and is more peaked than the normal distribution would suggest. Collectively, these sample statistics strongly indicate that positive ISD-differences are more likely to be drawn from the population than negative differences. This would provide evidence against the null hypothesis, suggesting that warrants appear to be valued higher than long term call options. It may, however, be questioned whether the assumption that the *WD*-observations are identically distributed is correct. More specifically, it can be argued that, since more volatile stocks have higher ISD-values, the variance of the distribution of the ISD-differentials for stocks with higher volatilities will be different (and probably higher) compared to low-volatility stock ISD-differential distributions. The preceding test would then be inadequate, since the estimator of the population mean will generally be inefficient. In order to resolve this problem we standardized the individual *WD*-values to *SWD*-observations, i.e.:

$$SWD_{it} \equiv \frac{WD_{it}}{s(WD_i)} \tag{2}$$

where $s(WD_i)$ is the estimated standard deviation of the *WD*-values in the corresponding year for warrant-call combination i. Each *SWD*-value may then be assumed to be drawn from a distribution with zero mean and unit variance. Consequently, the average *SWD*-value will be normally distributed in large samples with zero mean and variance equal to the inverse of the sample size (i.e. 1/N), such that the z-statistic

$$z \equiv \overline{SWD} \cdot \sqrt{N} \tag{3}$$

is asymptotically standard normally distributed. Panel (b) of table 2 provides data for this additional test. It can readily be seen that the conclusions that followed from panel (a) are strongly confirmed by the standardized observations. The mean *SWD*-value is positive for all years and all models and the z-statistic is everywhere significant at the 1% level. Therefore, these two overall tests suggest that the null hypothesis should be rejected.

It might appear from table 2 that there is some kind of decline in the mean differential over the consecutive years. In order to investigate this, we constructed two times series of the average weekly ISD-differentials over the warrant-call combinations for which there was an observation in the corresponding week, both for the non-standardized and the standardized observations. The resulting average weekly differentials in week t will be denoted by AWD_t and $ASWD_t$ respectively. To distinguish between the means for consecutive years, we propose a regression model with dummy variables for years 1988 and 1989 for both series:

$$AWD_t = \alpha_1 + \alpha_2 D88_t + \alpha_3 D89_t + \varepsilon_t \tag{4}$$

$$ASWD_t = \beta_1 + \beta_2 D88_t + \beta_3 D89_t + \eta_t \tag{5}$$

where $D88$ and $D89$ are dummy variables which are equal to one if and only if the observation applies to the corresponding year ($D88$ for 1988 and $D89$ for 1989). The basic assumptions for ordinary least squares regression analysis are assumed to hold for the error terms. Among other things, this requires that the observations are independent and that the variance is constant across observations. It was already argued that this latter requirement may be better fulfilled by the standardized observations. To further address this problem we also calculated heteroskedasticity consistent standard errors for the regression coefficients using the methodology proposed in White (1980). By simply replacing the OLS standard errors with these 'White' standard errors, standard tests of regression coefficients remain their validity in large samples. Table 3 presents summary data for the regression analysis.

[Insert Table 3]

The results for 1988 are somewhat confusing: the differentials from the Binomial model seem to be significantly higher than in 1987, whereas the estimators a_2 and b_2 are negative for the other two models. On the other hand, for 1989 all models reveal a significant (1% level) decline in the ISD-differential. The *F*-statistics all appear to be very significant. The White standard errors included in the non-standardized regressions indicate that potential heteroskedasticity problems are not very likely to influence the test results. Figures 2 and 3 visualize the *AWD*- and *SAWD*-observations in the consecutive years.

[Insert Figures 2 and 3]

Based on the results obtained thus far we conclude that the null hypothesis of zero ISD-differentials should be strongly rejected. Clearly, this holds for the entire research period and for all individual years. Furthermore, all option pricing models show significant positive differentials. Therefore, our study implies that warrants are valued significantly higher than long term call options in the years investigated. Furthermore, it appears that the pricing difference persisted during the whole 3-year period for virtually all warrant-call combinations. This conflicts sharply with the intuitive idea that warrants and long term call options are recognized by investors as similar contracts. The implied price difference was shown to be diminishing towards the end of the research period, but it remains highly significant.

Finally, two interesting facts deserve special attention. First, the warrants Akzo, included in the study, are callable, that is from November 1, 1988 Akzo has the right to bring back the maturity of these warrants to 3 months. In our calculations we have used the maximum maturity. This makes the case for Akzo particularly interesting: even if it is assumed that these warrants are non-callable, they appear to be overvalued relative to the long term call options Akzo. Second, the covered warrants Royal Dutch which are included also have significant positive ISD-differentials. Because the covered warrants give the right to buy existing shares of Royal Dutch, they can in fact be considered as long term call options. Notwithstanding this fact they seem to be regarded by investors as 'ordinary' warrants, i.e. they are overvalued relative to the long term (EOE) call options.

5 Additional evidence from short term call options

It was suggested before that the warrants investigated in the present study generally have somewhat longer maturities than the long term call options with which they are being compared. As a consequence, the results found for combinations of warrants and long term call options might be explained by the possibility that a particular time structure of volatility exists. In order to check for this, we introduced the sample of short term call option ISD-values detailed in section 4.1.. First of all, ISD-differences for combinations of warrants and short term calls were analyzed using an identical test methodology as described in the previous section. Table 4 presents sample statistics for these differences.

[Insert Table 4]

The data contained therein reveal that the ISD-values of warrants are also significantly higher (at the 1% level) than the corresponding short term call ISD-values, i.e for all periods and all models investigated. Furthermore, it is found from regressing (non-standardized and standardized) average weekly differences with respect to the year for which they are observed (using the specification given in equations (4) and (5)) that, according to the results given in table 5 and in figures 4 and 5, the difference diminishes slowly but significantly.

[Insert Table 5 and Figures 4 and 5]

Thus, the results found for both warrants vs. long calls and warrants vs. short term appear to be very consistent with each other. However, this may still be explained by the existence of a time structure of volatility. To provide for conclusive evidence with respect to this, we also tested long calls vs. short calls. Tables 6 and 7 and figures 6 and 7 present the results for this test which was again carried out following the methodology discussed previously.

[Insert Tables 6 and 7 and Figures 6 and 7]

These figures show, however, that the warrant-call findings are unlikely to be explained by a time to maturity bias. To see this it should be noted that if such an effect would indeed be present in the current sample, we would also expect that the ISD-difference between long and short term calls is (significantly) positive. It can be seen that especially for the years 1987 and 1988, in which the warrant-call differences are most high, the long-short call difference are significantly negative for virtually all models. Later on in the sample these differences tend to rise, becoming positive in 1989. These latter findings, therefore, strongly suggest that a time to maturity effect is highly unlikely to explain the warrant-call results. It may also be noted that the Square Root model provides evidence which is mostly, if not always, consistent with the other models. This implies that our empirical findings may probably neither be explained by the possible existence of an exercise price bias.

6 Summary and conclusions

In this paper, an empirical study is carried out in order to investigate the hypothesis that two contracts contingent on the same underlying value should have the same value, if they are compared in an appropriate manner. Since warrants are generally regarded as long term call options, we have compared daily ISD-values using three option pricing models: the Binomial model, the Merton model, and the Square Root CEV model. Our study reveals substantial ISD-differentials, indicating a large overvaluation of warrants in the Dutch capital market. This is an anomalous result, because existing finance theory is unable to explain it. Despite some tendency to decline in the last year of our research period, these ISD-differentials remain significantly positive. The suggestion that our findings might be generated by the possible existence of a time to maturity effect is contradicted by the additional evidence provided by the short term call options sample, which shows that the largest positive warrant-call ISD-differences are associated with the largest *negative* ISD-differences for long vs. short term calls. As detailed in the appendix, some existing market imperfections or institutional factors would provide arguments which could be used to explain the anomaly, but they do not appear to be able to fully explain the large and persistent differences between warrants and long term call options.

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Appendix: Market imperfection related differences between warrants and call options.

The following imperfection related aspects can be investigated: standardization, taxes, liquidity, dividend protection, transaction costs, the relation of the warrant-ratio to the option-ratio, and possible restrictions for large investors. These will be discussed below.

Standardization

Call options are more standardized than warrants. That is because the EOE determines standardized conditions for call options, while the ASE does not specify such conditions for warrants. We consider this as an advantage for call options in relation to warrants.

Taxes

In case Dutch investors buy warrants or options on respectively the Stock or the Options Exchange, Dutch tax law considers the payoffs from all such contracts as capital gains and therefore exempts them from Dutch income tax. Thus, warrants and call options are taxed in the same way.

Liquidity

One factor that may be different for warrants and call options is their 'liquidity'. Sharpe and Alexander (1990, page 233) refer to liquidity as 'the cost of selling or buying a security "in a hurry"', or more precisely (page 805): 'the ability to sell an asset quickly without having to make a substantial price concession'. They (page 234) also argue that the liquidity of a security may be measured by the size of the spread between bid and ask prices. Of course, smaller spreads suggest greater liquidity. We notice however, that a comparison of the bid-ask spread between warrants and call options is not possible, because only for call options a bid-ask spread exists. In this context it is interesting to shortly look at the trading systems of the ASE and the EOE[8]. The trading system on the ASE is primarily an "order driven system". On the ASE each security is traded in a so-called "hoek". In each "hoek" at least two "hoekmen" compete in trading the respective security in which they are allowed to take orders. Based on the orders received the hoekmen determine a price. The hoekmen themselves may also take positions and serve as market makers. Trading on the EOE, on the other hand, primarily takes place in the form of a "quote driven system". In this system market makers compete with each other by giving bid- and ask quotes. The spread between these bid- and ask quotes is tied to a maximum, depending on the option premium. The market maker that gives the highest bid price and/or the lowest ask price has the right to execute a possible transaction. Considering the trading systems the liquidity of the EOE seems to be somewhat better than that of the ASE, because it is always possible to buy or sell a security for the ask or the bid price.

As a second aspect of liquidity we mention the fact, that the number of outstanding warrants is fixed. The warrant-issuer has brought a specific issue to the market, existing of a fixed number of contracts. The number of contracts can only be increased if the company brings a new issue to the market. Contrary to this, the number of call option contracts is flexible; it depends on the number of option writers on one side and the number of option buyers on the other side. In other words the supply of warrants is rather inelastic, whereas the supply of call options is almost perfectly elastic. Of course, this liquidity aspect also favors call options over warrants.

Third, trading volumes of warrants and call options can be considered. Veld (1992) has compared these volumes for 1989. From this comparison he concludes that the volume of warrants is on average larger than that of long term call options. This is also the case if the volumes are corrected for time and the number of shares that can be bought with one warrant or one call option. Therefore we conclude that from this viewpoint the liquidity of warrants seems to be better than that of long term call options, so liquidity in some cases may favor (long term) call options and in other cases it may favor warrants.

Dividend protection

Warrants and call options are both protected against the distribution of large stock dividends, preemptive rights or bonus shares to existing shareholders. This protection is settled in an anti-dilution clause. Upon research Veld (1992) concludes that Dutch warrants are generally not fully protected against a decline in their theoretical bottom value, because mostly only the exercise price is lowered, while full protection also requires an increase of the warrant-ratio. He also concludes that, in case of large issues of bonus shares, call options are completely protected against a decline in their theoretical bottom value. On the other hand, it can be observed in practice that in case of a choice with respect to dividend type (in cash or in shares), anti-dilution clauses are applied for warrants, while they are not applied for EOE call options. This makes that the application of anti-dilution clauses in some cases favors (long term) call options and in other cases it favors warrants.

Transaction costs

From calculations of transaction costs for warrants and call options Veld (1992) concludes that these costs are somewhat lower for warrants than for call options. However, the marginal difference is decreasing when larger volumes are considered.

The relation of the warrant-ratio to the option-ratio

While (EOE) call options on stocks are always issued with an option-ratio of 100, the warrant-ratio at the date of issue is generally much smaller. Therefore the investment in warrants is generally smaller than the investment in long term call options. If we consider e.g. the Philips example of section 2, we see that on April 8, 1987 an investment in the option would require 100**f* 10.30 = *f* 1030, while an investment in the warrant would require only 20**f* 14.90 = *f* 298. This can be considered as an advantage for warrants. However, this advantage is only important for (very) small investments.

Restrictions for large investors

Some colleague researchers suggested that price differentials between warrants and call options may be partially explained if it is true that large financial institutions, such as pension funds, are formally restricted with respect to investing in call options. It would follow that such institutions, if they want to hold contingent contracts in their portfolios, they would have to resort to warrants, thereby creating excess demand for warrants. However, this explanation is inappropriate for the present study because Veld (1992) concludes from several interviews with large Dutch institutional investors that virtually no such investor ever experienced formal restrictions of this type.

Notes:

1. This may be illustrated by some figures for 1989, provided by the EOE. Trading in long term options (calls and puts) which existed for five major Dutch stocks in 1989 amounted to almost 12% of the total trading volume with respect to options on these stocks. The total volume of long term option contracts traded in 1989 was almost 600,000, which was nearly 6% of total stock options trading in 1989.

2. On October 5, 1990 the Dutch example was followed by the Chicago Board of Options Exchange (CBOE), which introduced call options with a maturity of 2 years on the shares of 14 US multinationals. Earlier the CBOE started trading in long term call options on the Standard & Poor's 500 Index.

3. It should be noted that the models of Schulz and Trautmann (1989) and Crouhy and Galai (1991a) assume that firms have only warrants and stocks outstanding. Crouhy and Galai (1991b) and Jarrow and Trautmann (1992) present warrant pricing models based on firms that also include debt financing. As far as we know no numerical results on the difference between the prices generated by these models and Black-Scholes prices are available.

4. The long term call-options with maturities of 5 years were not yet outstanding in the research period used by Kemna.

5. Studies of Beckers (1980) and MacBeth and Merville (1980) show better predictions of call-option prices for models of the CEV-class, while results found by Rubinstein (1985) and to some extent Emanuel and MacBeth (1982) give rise to doubt this superior performance over models of the CV-class. Regarding the pricing of warrants, results found by Lauterbach and Schultz (1990) in favor of one of the CEV-models are

contradicted by results of Noreen and Wolfson (1981), Schulz and Trautmann (1989) and Stucki and Wasserfallen (1991) who all deny the superior performance of CEV-models in relation to CV-models.

6. Future dividends were estimated using realized dividend payments in the one year period preceding the estimation date. At each realized ex-dividend date, the estimation of the future dividends was adjusted based on the new dividend information.

7. More specifically, ISD values were calculated using the closing price data of each week's tuesday, wednesday and thursday.

8. For a description of the trading systems on the EOE and the ASE, see Berkman (1992).

Table 1: Warrants, call options and covered warrants listed from April 1, 1987 to September 30, 1989.

Listed securities	Range of exercise prices during the research period (in guilders)	Issue date	Expiration date
ABN			
warrants 1986	594.60 - 59.46	June 15, 1986	May 14, 1996
9-month calls	miscellaneous	miscellaneous	
AKZO			
warrants 1986	120.00 - 119.00	Oct. 16, 1986	Sept. 30, 1991
5-year calls 1986	150.00	Oct. 20, 1986	Oct. 18, 1991
5-year calls 1987	180.00	Oct. 19, 1987	Oct. 16, 1992
5-year calls 1988	150.00	Oct. 24, 1988	Oct. 15, 1993
9-month calls	miscellaneous	miscellaneous	
AMRO			
warrants 1986S [a)]	114.50 - 109.10	May 5, 1986	Dec. 15, 1989
warrants 1986B [b)]	120.00 - 114.00	Sept. 16, 1986	Sept. 14, 1991
9-month calls	miscellaneous	miscellaneous	
KLM			
warrants 1983	33.50	March 23, 1983	March 15, 1988
warrants 1985	53.00	March 5, 1985	Febr. 29, 1992
5-year calls 1986	40.00	Oct. 20, 1987	Oct. 18, 1991
5-year calls 1987	55.00	Oct. 19, 1987	Oct. 16, 1992
5-year calls 1988	35.00	Oct. 24, 1988	Oct.15, 1993
9-month calls	miscellaneous	miscellaneous	
KNP			
warrants 1989	55.00	April 3, 1989	Nov. 30, 1993
9-month calls	miscellaneous	miscellaneous	
NATIONALE NEDERLANDEN			
warrants 1976	22.20	June 15, 1976	June 15, 1988
warrants 1978	25.06	Aug. 1, 1978	Aug. 1, 1988
9-month calls	miscellaneous	miscellaneous	

Table 1 (continued)

PHILIPS			
warrants 1983	52.70	July 14, 1983	July 15, 1988
warrants 1984	63.00 - 61.80	Nov. 16, 1984	Nov. 30, 1989
5-year calls 1986	55.00	Oct. 20, 1986	Oct. 18, 1991
5-year calls 1987	55.00	Oct. 19, 1987	Oct. 16, 1992
5-year calls 1988	35.00	Oct. 24, 1988	Oct. 15, 1993
9-month calls	miscellaneous	miscellaneous	
ROYAL DUTCH			
covered			
warrants 1986	195.00 - 97.50	June 6, 1986	June 4, 1991
5-year calls 1986	210.00 - 105.00	Oct. 20, 1986	Oct. 18, 1991
5-year calls 1987	270.00 - 135.00	Oct. 19, 1987	Oct. 16, 1992
5-year calls 1988	115.00	Oct. 24, 1988	Oct. 15, 1993
9-month calls	miscellaneous	miscellaneous	
UNILEVER			
5-year calls 1986	500.00 - 100.00	Oct. 20, 1986	Oct. 18, 1991
5-year calls 1987	140.00	Oct. 19, 1987	Oct. 16, 1992
5-year calls 1988	120.00	Oct. 24, 1988	Oct. 15, 1993
9-month calls	miscellaneous	miscellaneous	
VAN OMMEREN			
warrants 1987A	40.00	June 1, 1987	May 31, 1990
warrants 1987B	43.50	June 1, 1987	May 31, 1992
9-month calls	miscellaneous	miscellaneous	

[a]issued in combination with shares of common stock;
[b]issued in combination with ordinary bonds.

Table 2: Sample statistics for WD- and SWD-observations (warrants vs. long calls)

(a) WD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	113	161	161	198	193	193	154	262	262	465	616	616
Mean	0.208	0.174	0.165	0.237	0.138	0.151	0.061	0.048	0.048	0.172	0.109	0.111
Variance	0.032	0.026	0.021	0.029	0.009	0.015	0.005	0.004	0.004	0.028	0.014	0.015
t-statistic	12.42	13.8	14.53	19.68	20.72	17.21	10.7	12.75	12.77	22.22	22.98	22.77
Highest	0.701	0.732	0.642	0.817	0.362	0.439	0.239	0.211	0.249	0.817	0.732	0.642
Lowest	-0.073	-0.073	-0.052	-0.047	0.013	-0.003	-0.072	-0.096	-0.069	-0.073	-0.096	-0.069
Skewness	0.777	1.258	1.053	0.817	0.979	1.192	0.805	0.241	0.942	1.126	1.728	1.523
Kurtosis	0.517	1.723	0.731	1.159	-0.161	-0.055	-0.033	0.175	1.221	1.44	4.67	2.143

(b) SWD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	113	161	161	198	193	193	154	262	262	465	616	616
Mean	5.526	4.102	4.001	4.801	5.458	5.332	2.089	2.04	1.91	4.079	3.65	3.528
z-statistic	58.75	52.05	50.76	67.55	75.83	74.07	25.93	33.02	30.91	87.96	90.59	87.57
Highest	16.43	14.24	13.85	15.24	11.18	9.788	8.376	8.344	7.249	16.43	14.24	13.85
Lowest	-2.59	-2.31	-1.677	-1.787	0.439	-0.102	-1.757	-2.49	-2.163	-2.59	-2.49	-2.163

Note: this table gives statistics for weekly differences between warrant and long term call options implied standard deviations, which both measure the standard deviation of the instantaneous rate of return on the underlying stock. Panels (a) and (b) provide data for non-standardized and standardized observations, respectively. The three columns given for each (sub)period refer to the Binomial model, the Merton model, and the Square Root CEV model.

Table 3: Regression results for AWD- and ASWD-observations (warrants vs. long calls)

(a) AWD-observations

	a1	*a2*	*a3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	0.213	0.025	-0.156	0.795	147.147	0.000
St. error	0.008	0.011	0.011			
t-statistic	26.747	2.187	-13.754			
White st.err.	0.011	0.012	0.013			
Mer						
Coeff.	0.173	-0.034	-0.126	0.830	185.576	0.000
St. error	0.005	0.007	0.007			
t-statistic	36.611	-5.062	-18.681			
White st.err.	0.006	0.006	0.006			
SqR						
Coeff.	0.165	-0.012	-0.119	0.817	169.317	0.000
St. error	0.005	0.007	0.007			
t-statistic	33.363	-1.749	-16.821			
White st.err.	0.006	0.008	0.007			

(b) ASWD-observations

	b1	*b2*	*b3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	5.850	-1.022	-3.887	0.653	71.458	0.000
St. error	0.235	0.336	0.336			
t-statistic	24.853	-3.042	-11.567			
Mer						
Coeff.	4.098	1.373	-2.072	0.899	339.570	0.000
St. error	0.092	0.132	0.132			
t-statistic	44.364	10.413	-15.710			
SqR						
Coeff.	3.997	1.354	-2.117	0.890	307.514	0.000
St. error	0.098	0.140	0.140			
t-statistic	40.805	9.686	-15.143			

Note: the figures in panels (a) and (b) refer to AWD- and ASWD-observations, respectively. For each regression coefficient, the table lists the estimated value, the standard error, and the t-statistic for the test that the coefficient is zero. Panel (a) also provides heteroskedasticity consistent standard errors as proposed by White (1980). The three blocks in each panel correspond to the Binomial model, the Merton model, and the Square Root CEV model.

Table 4: Sample statistics for WD- and SWD-observations (warrants vs. short calls)

(a) WD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	179	278	275	154	182	182	162	242	242	495	702	699
Mean	0.131	0.199	0.162	0.116	0.124	0.156	0.032	0.078	0.08	0.094	0.138	0.1321
Variance	0.028	0.041	0.023	0.021	0.014	0.024	0.024	0.005	0.007	0.026	0.024	0.019
t-statistic	10.52	16.46	17.9	9.873	14.15	13.53	2.652	16.5	14.91	12.89	23.44	25.37
Highest	0.634	0.876	0.625	0.439	0.459	0.597	0.291	0.259	0.289	0.634	0.876	0.625
Lowest	-0.095	-0.104	-0.095	-0.36	-0.099	-0.302	-0.686	-0.109	-0.123	-0.686	-0.109	-0.302
Skewness	0.865	0.676	0.319	0.438	0.962	1.072	-1.135	0.05	0.272	0.116	1.341	0.8955
Kurtosis	0.369	-0.34	-0.559	-0.139	0.29	0.931	3.013	-0.495	-0.258	1.782	1.823	0.7933

(b) SWD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	179	278	275	154	182	182	162	242	242	495	702	699
Mean	3.447	4.004	3.598	2.462	3.14	3.171	0.907	2.649	2.671	2.309	3.313	3.1659
z-statistic	46.12	66.76	59.67	30.55	42.36	42.78	11.54	41.21	41.55	51.38	87.78	83.702
Highest	16.43	14.24	13.85	6.5	8.311	7.153	5.454	10.35	9.517	16.43	14.24	13.853
Lowest	-4.235	-5.655	-3.9	-5.031	-2.785	-4.204	-3.771	-3.155	-2.84	-5.031	-5.655	-4.204

Note: this table gives statistics for weekly differences between warrant and long term call options implied standard deviations, which both measure the standard deviation of the instantaneous rate of return on the underlying stock. Panels (a) and (b) provide data for non-standardized and standardized observations, respectively. The three columns given for each (sub)period refer to the Binomial model, the Merton model, and the Square Root CEV model.

Table 5: Regression results for AWD- and ASWD-observations (warrants vs. short calls)

(a) AWD-observations

	a1	*a2*	*a3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	0.132	-0.016	-0.102	0.568	49.906	0.000
St. error	0.008	0.011	0.011			
t-statistic	17.215	-1.451	-9.325			
White st.err.	0.005	0.007	0.012			
Mer						
Coeff.	0.198	-0.074	-0.119	0.785	138.857	0.000
St. error	0.005	0.007	0.007			
t-statistic	38.946	-10.199	-16.488			
White st.err.	0.007	0.008	0.007			
SqR						
Coeff.	0.161	-0.006	-0.081	0.622	62.535	0.000
St. error	0.006	0.008	0.008			
t-statistic	28.580	-0.686	-10.064			
White st.err.	0.006	0.009	0.007			

(b) ASWD-observations

	b1	*b2*	*b3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	3.497	-1.036	-2.604	0.706	91.432	0.000
St. error	0.136	0.194	0.194			
t-statistic	25.784	-5.350	-13.447			
Mer						
Coeff.	4.011	-0.871	-1.370	0.468	33.427	0.000
St. error	0.119	0.170	0.170			
t-statistic	33.714	-5.127	-8.065			
SqR						
Coeff.	3.598	-0.428	-0.937	0.269	13.990	0.000
St. error	0.124	0.177	0.177			
t-statistic	28.993	-2.413	-5.286			

Note: the figures in panels (a) and (b) refer to AWD- and ASWD-observations, respectively. For each regression coefficient, the table lists the estimated value, the standard error, and the t-statistic for the test that the coefficient is zero. Panel (a) also provides heteroskedasticity consistent standard errors as proposed by White (1980). The three blocks in each panel correspond to the Binomial model, the Merton model, and the Square Root CEV model.

Table 6: Sample statistics for WD- and SWD-observations (long calls vs. short calls)

(a) WD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	84	135	135	241	245	245	258	378	379	583	758	759
Mean	-0.04	0.005	-0.008	-0.007	-0.008	0.004	-0.005	0.041	0.032	-0.011	0.018	0.016
Variance	0.001	0.003	0.002	0.004	0.003	0.006	0.002	0.004	0.003	0.003	0.004	0.004
t-statistic	-11.82	1.05	-1.956	-1.688	-2.288	0.918	-1.839	12.17	11.8	-4.874	7.971	6.951
Highest	0.021	0.161	0.133	0.142	0.129	0.191	0.11	0.317	0.236	0.142	0.317	0.236
Lowest	-0.147	-0.06	-0.088	-0.44	-0.172	-0.394	-0.173	-0.084	-0.085	-0.44	-0.172	-0.394
Skewness	-1.03	1.334	1.072	-1.746	0.031	-0.497	-0.425	1.29	1.052	-1.191	0.959	0.004
Kurtosis	1.3054	0.879	0.55	10.91	-0.156	4.426	0.593	2.14	1.607	8.758	2.029	4.041

(b) SWD-observations

	1987			1988			1989			1987-1989		
	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR	Bin	Mer	SqR
# Observations	84	135	135	241	245	245	258	378	379	583	758	759
Mean	-2.277	-0.271	-0.627	-0.074	-0.567	0.046	-0.159	1.354	1.195	-0.429	0.444	0.5
z-statistic	-20.87	-3.153	-7.284	-1.154	-8.868	0.715	-2.549	26.32	23.26	-10.36	12.21	13.77
Highest	0.7052	4.393	3.993	5.457	4.647	5.392	4.865	6.671	6.281	5.4573	6.671	6.281
Lowest	-7.459	-4.496	-3.876	-5.733	-6.73	-6.311	-5.211	-3.508	-3.484	-7.459	-6.73	-6.311

Note: this table gives statistics for weekly differences between warrant and long term call options implied standard deviations, which both measure the standard deviation of the instantaneous rate of return on the underlying stock. Panels (a) and (b) provide data for non-standardized and standardized observations, respectively. The three columns given for each (sub)period refer to the Binomial model, the Merton model, and the Square Root CEV model.

Table 7: Regression results for AWD- and ASWD-observations (long calls vs. short calls)

(a) AWD-observations

	a1	*a2*	*a3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	-0.038	0.031	0.034	0.345	20.031	0.000
St. error	0.004	0.006	0.006			
t-statistic	-9.078	5.251	5.655			
White st.err.	0.004	0.006	0.005			
Mer						
Coeff.	0.005	-0.011	0.036	0.561	48.621	0.000
St. error	0.003	0.005	0.005			
t-statistic	1.362	-2.303	7.226			
White st.err.	0.003	0.005	0.004			
SqR						
Coeff.	-0.008	0.014	0.040	0.383	23.624	0.000
St. error	0.004	0.006	0.006			
t-statistic	-2.046	2.440	6.797			
White st.err.	0.003	0.007	0.004			

(b) ASWD-observations

	b1	*b2*	*b3*	*R-sq.*	*F*	*Sign. F*
Bin						
Coeff.	-2.194	2.146	2.094	0.612	59.932	0.000
St. error	0.157	0.224	0.224			
t-statistic	-13.964	9.566	9.333			
Mer						
Coeff.	-0.271	-0.238	1.616	0.594	55.681	0.000
St. error	0.133	0.190	0.190			
t-statistic	-2.042	-1.253	8.516			
SqR						
Coeff.	-0.627	0.721	1.815	0.553	46.993	0.000
St. error	0.132	0.188	0.188			
t-statistic	-4.753	3.827	9.639			

Note: the figures in panels (a) and (b) refer to AWD- and ASWD-observations, respectively. For each regression coefficient, the table lists the estimated value, the standard error, and the t-statistic for the test the coefficient is zero. Panel (a) also provides heteroskedasticity consistent standard errors as proposed by White (1980). The three blocks in each panel correspond to the Binomial model, the Merton model, and the Square Root CEV model.

Figure 1: Comparison of warrant and long term call option market prices of Philips in 1987 and 1988

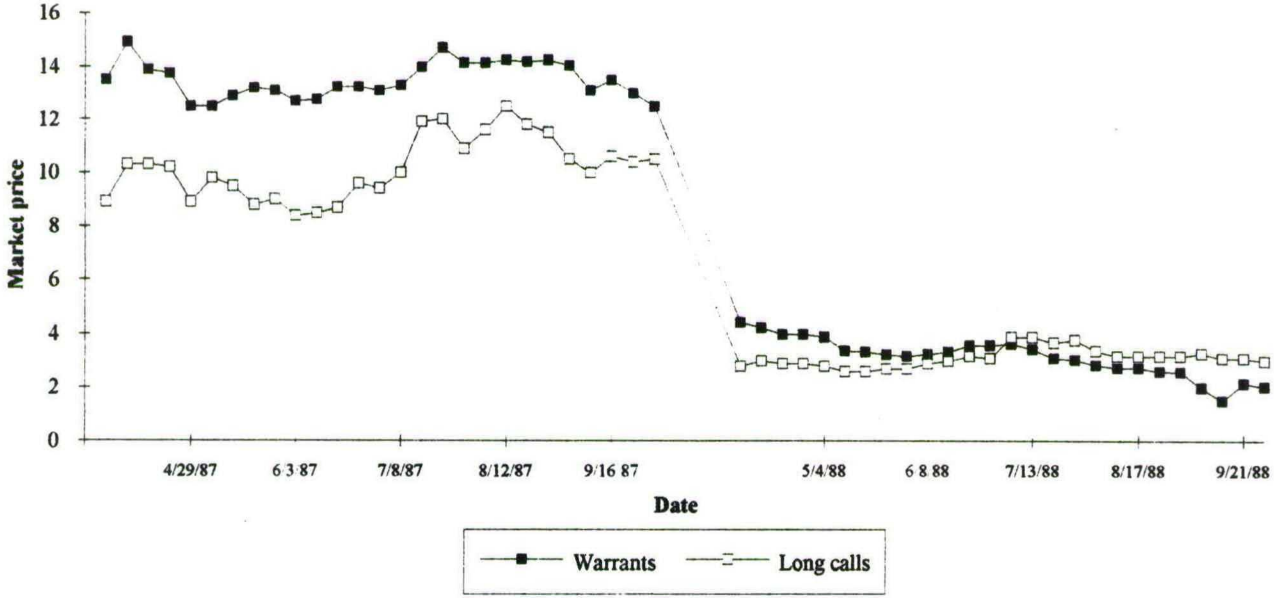


Figure 2: AWD-observations for 1987-1989 (warrants vs. long calls)

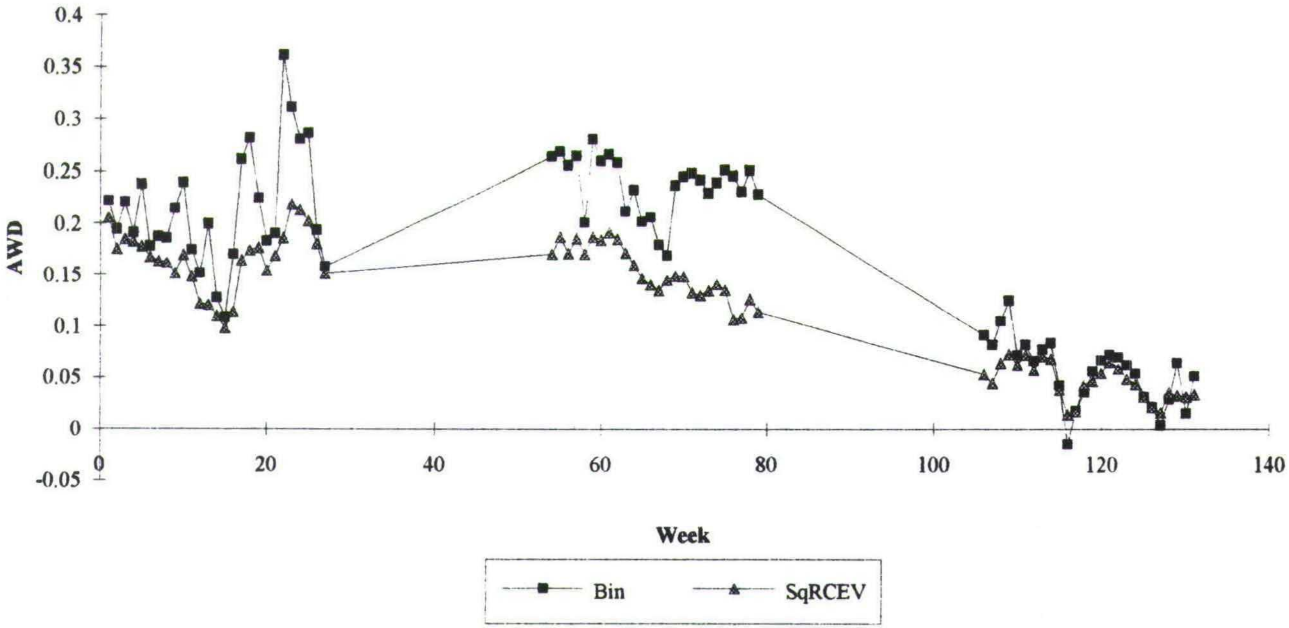


Figure 3: ASWD-observations for 1987-1989 (warrants vs. long calls)

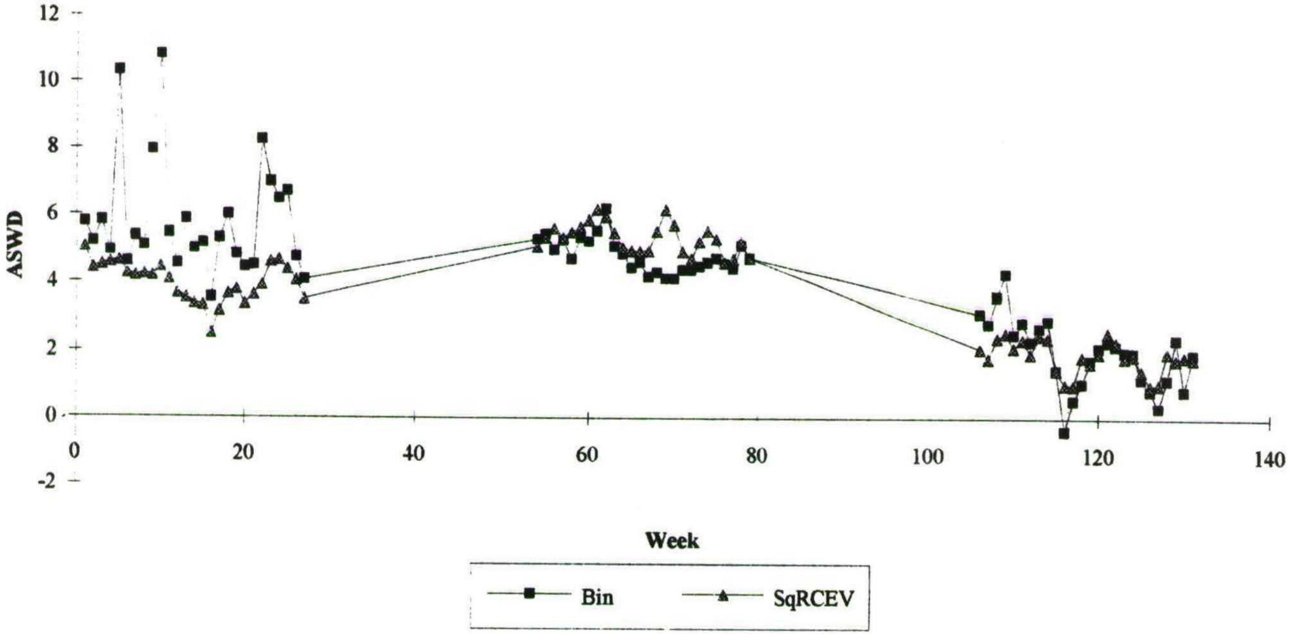


Figure 4: AWD-observations for 1987-1989 (warrants vs. short calls)

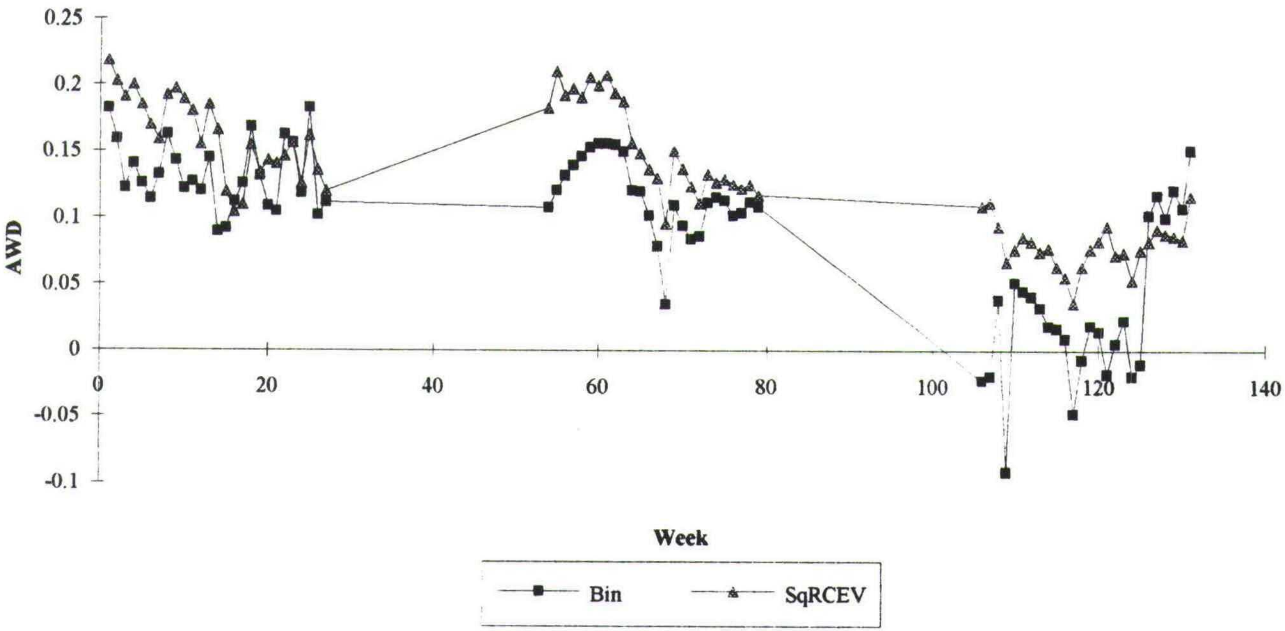


Figure 5: ASWD-observations for 1987-1989 (warrants vs. short calls)

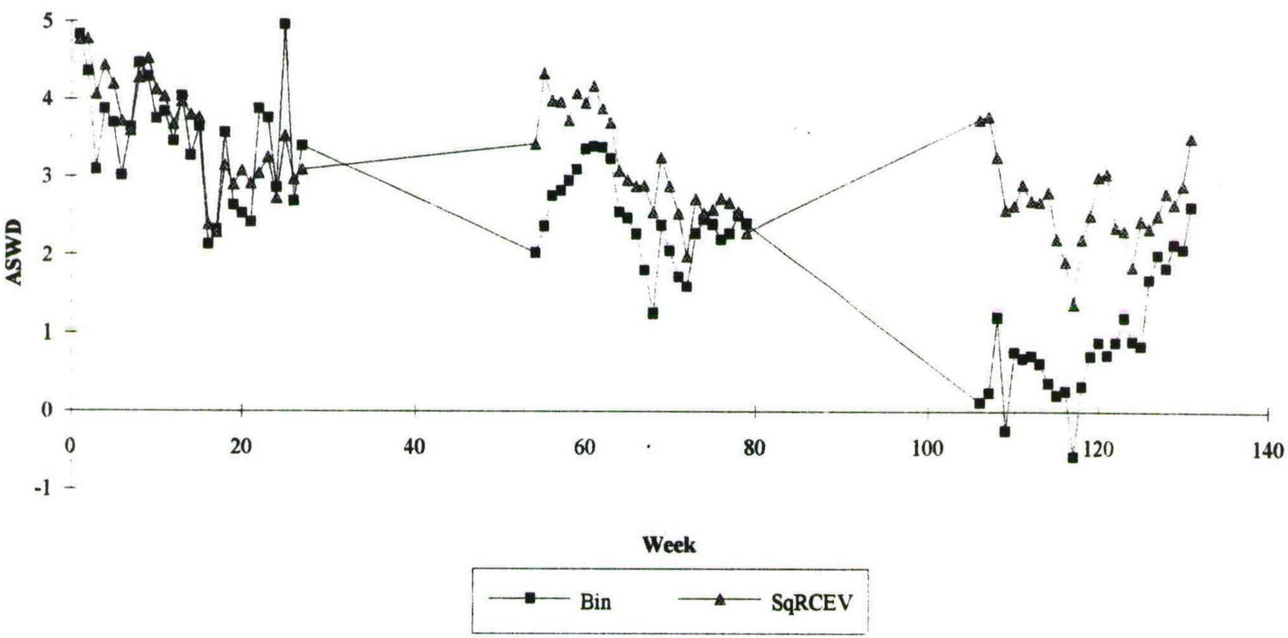


Figure 6: AWD-observations for 1987-1989 (long calls vs. short calls)

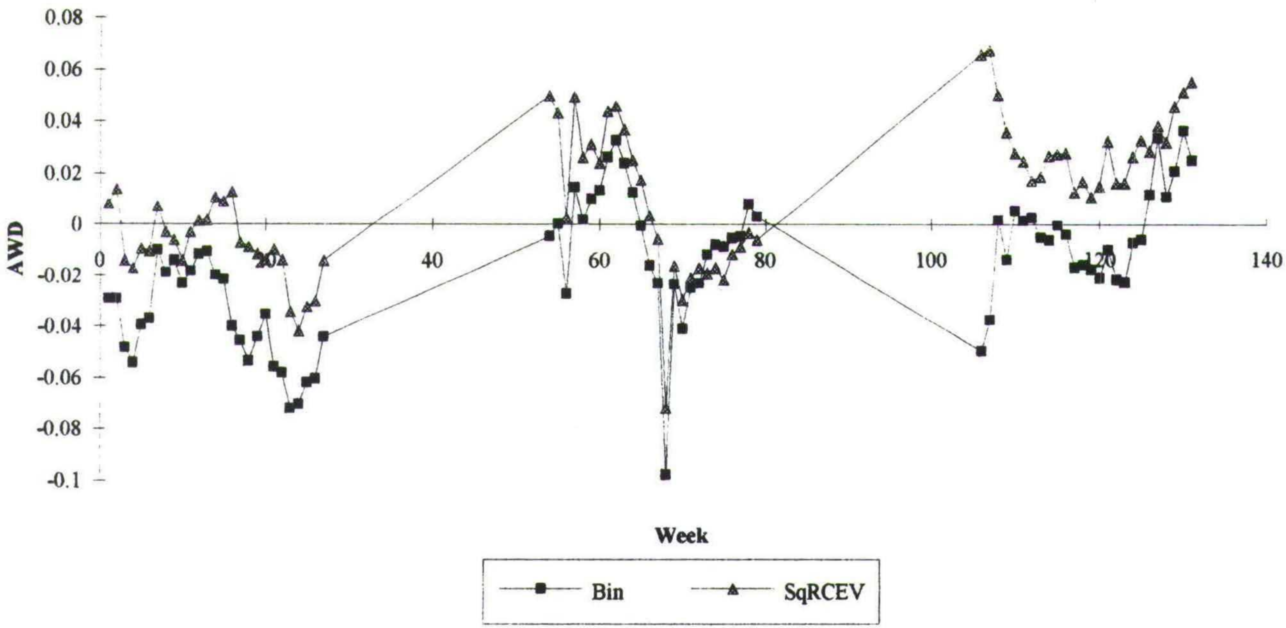
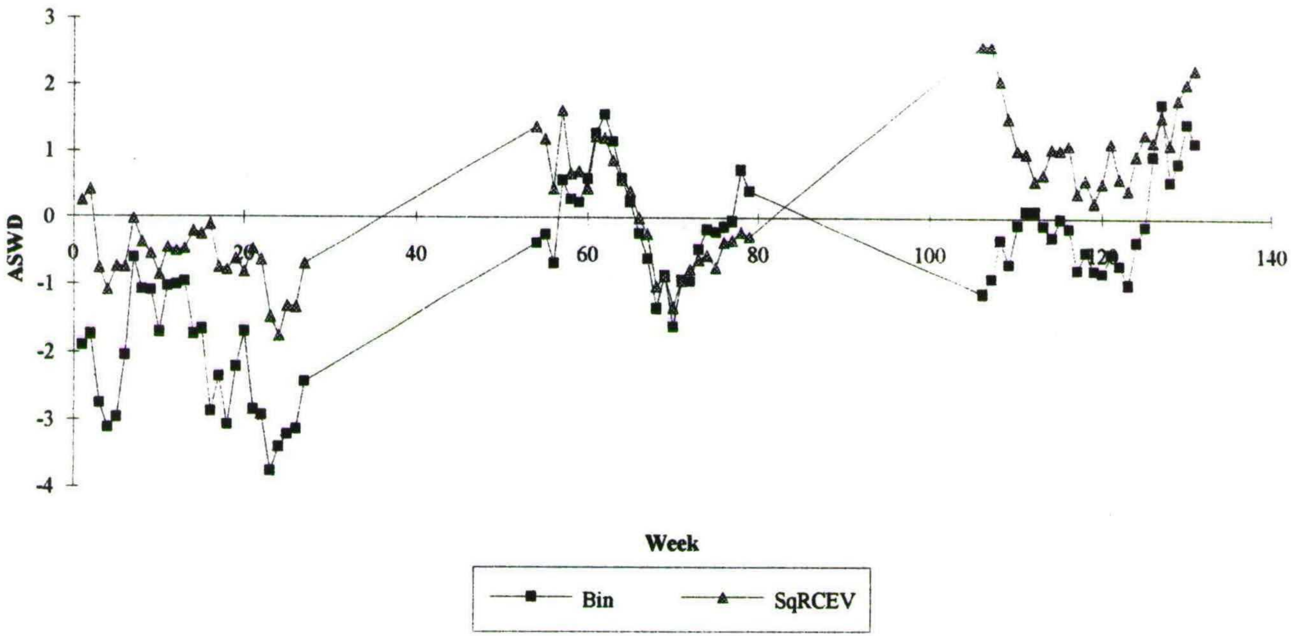


Figure 7: ASWD-observations for 1987-1989 (long calls vs. short calls)



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